Simulating deforestation of Nepal by area production model

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Abstract: Based on the growth rates of population, Gross Domestic Products (GDP) and agriculture productivity, the areas of deforestation were predicted in Jutpani village, Chitwan district, Nepal by Area Production Model (APM). Through the APM simulation in this study, all of forestland will be transferred into agricultural land in 2030 at the rate of 24% per year on the current productivity. And if the productivity of subsistence food crop is assumed to increase at the rate of 1%, the productivity of market crop and export crop increase at the rate of 2% annually, deforestation rate will decrease to 17% per year, but only 124 hm^2 forest land will be left till 2038. The agriculture productivity is a very important factor for the deforestation, so intensification of agriculture management is more important.

Key words: Area Production Model (APM); Simulation, deforestation; Gross Domestic Products (GDP); Subsistence food crop; Market food crop
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Introduction

Deforestation is one of the major environmental problems that confront the world today. The main reasons of deforestation are logging, human activities, animal grazing and natural factors (e.g. forest fire, storms etc., Hussin *et al.* 1995). Food and Agriculture Organization (FAO 1997) also said that the major causes of change in forest cover in the developing country appear to be expansion of subsistence agriculture, large economic development programs involving resettlement.

Forest degradation and deforestation are also serious problems in Nepal. Forest covered most of the parts of country in the past. It has declined in terms of quality and quantity at alarming rate since last 4 decades and still continuing. Most of the population depended entirely on the forest for livelihood and socio-economic development. Forest plays a vital role in the daily subsistence life in the poor rural area.

Despite various efforts for protection and conservation, the process of deforestation is unlikely to be ceased. As long as the demand for agriculture land is not satisfied, deforestation is likely to continue. In most cases, the expansion of agriculture land is accomplished at the expense of the forest depletion. In order to predict the forest future and give foresters or planners some ideas how to prevent forest depletion, mathematical model usually is applied. One of the computer programs that can predict the future land use change and deforestation is the Area Production Model (APM).

APM plays an important role in land use planning and can be utilized to simulate land use changes, which can yield useful information on the impact of changes with increasing demand for more agricultural areas. APM is used to simulate future demand and deforestation based on the growth rates of population, gross domestic products (GDP) and agriculture productivity.

APM and data

APM was developed as a planning land tool in the 1980's for the Food and Agriculture Organization (FAO 1986). The main objectives of APM are to assist in the development scenarios and give guidelines for strategic land use and forestry planning of an area unit. Simulation period could be extended up to 50 years in a step of 5-year period.

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APM uses three different agricultural classes, such as land for subsistence food crop (used mainly for home consumption), land for market food crop (produced mainly for the local markets), and land for export food crop (destined primarily for markets outside the area to improve the life quality).

APM requires two different types of input data. One is to describe the present situation of area (e.g. forest resources, land use) and the other for projection future trends (e.g. growth rates of population, GDP and agricultural productivity). Therefore, the demand area for new agricultural land is calculated based on the following formulas:

Productivity of subsistence food crop:
$D_1 = P_1 \times G_p / G_1$
Productivity of market food crop: $D_2 = P_2 \times G_G / G_2$
Productivity of export food crop: $D_3 = P_3 \times G_G / G_3$
Where:
P_1 --present area of subsistence food crop (hm^2);
P_2 --present area of market food crop (hm^2);
P_3 --present area of export food crop (hm^2);
D_1--demand area for subsistence food crops (hm^2);
D_2--demand area for market food crops (hm^2);
D_3--demand area for export food crops (hm^2);
G_p--growth rate of population;
G_1, G_2, G_3--growth rates of productivity of subsistence food crop, market food crop, and export food crop;
G_G--growth rate of gross domestic products.

APM has been tested and yielded adequate results in several tropical countries like East Java, Indonesia and Ratchaburi, Thailand and Peru (Hussin *et al.* 1994, 1995).

Study area

The study area, Jutpani village, is located in the north-western part of Chitwan district, which is located in central part of Terai, 100 km south from the capital Kathmandu, Nepal. It lies between latitude from 27°21'45"N to 27°52'30"N and longitude from 83°54'45"E to 84°48'15"E. The total area is approximately 1 445 hm^2.

In Nepal, more than 90% of the population is located in rural areas. Nepal's population growth rate increased from 2.06% in 1970's to 2.50% in 1998. Large forest area was clear-cut or is going to be clear-cut for new residents, and with more and more population for need in more and more fuel wood and timber for their subsistence life. As a consequence, forest burden becomes heavy and the speed of deforestation is accelerated. Data of the agriculture productivity were provided by the local agriculture office (CBS 1998; FORESC 1999).

In order to determine the influence of growth factors on the land transfers, two scenarios were developed: scenario 1 based on the increase of the crop productivity after 2000 year and scenario 2 based on the current crop productivity keeping constant during the simulation period. Other factors, population growth rate and GDP were assumed the same in these two scenarios. Through changing the growth factors we can get some ideas on the land tranfers and deforestation speed in the study area. For the land planners and foresters, they should pay more attention to the high pressure of deforestation area. The growth factors in scenatio 1 and scenario 2 were listed in Table 1 and Table 2, respectively

Results and analysis

According to APM, the simulation results in scenario 1 are shown as Fig. 1.

Fig. 1 showed the trend of land use transfer till 2038. The result indicates that the expansion of agriculture land will continue to increase but at a decrease pace. Forestland decreases at a rate of 17% per year according to the simulation results.

Table 1. Growth factors in scenario 1

5-year period	Population		GDP	Crop productivity		
	Total	Rural		Subsistence crop	Market crop	Export crop
1988-1993	1.021	1.021	1.020	1.009	1.010	1.010
1993-1998	1.023	1.023	1.020	0.998	1.010	1.010
1998-2003	1.030	1.030	1.015	0.998	1.015	1.015
2003-2008	1.030	1.030	1.015	1.000	1.015	1.015
2008-2013	1.027	1.027	1.020	1.010	1.020	1.020
2013-2018	1.025	1.025	1.026	1.010	1.020	1.020
2018-2023	1.025	1.025	1.026	1.010	1.020	1.020
2023-2028	1.025	1.025	1.026	1.010	1.020	1.020
2028-2033	1.025	1.025	1.026	1.010	1.020	1.020
2033-2038	1.025	1.025	1.026	1.010	1.020	1.020

The results simulated in scenario 2 were shown in Fig. 2. If agriculture activities still keep the present situation, i.e. productivity of subsistence food crop is no growth, productivity of market food crop and export food crop increase at the rate of 1.5% per year, the need for agricultural land will be at increasing pace. And the forestland also will be depleting at an accelerated rate.

Table 2. Growth factors in scenario 2

5-year period	Population		GDP	Crop productivity		
	Total	Rural		Subsistence crop	Market crop	Export crop
1988-1993	1.021	1.021	1.020	1.009	1.010	1.010
1993-1998	1.023	1.023	1.020	0.998	1.010	1.010
1998-2003	1.030	1.030	1.015	0.998	1.015	1.015
2003-2008	1.030	1.030	1.015	1.000	1.015	1.015
2008-2013	1.027	1.027	1.020	1.000	1.015	1.015
2013-2018	1.025	1.025	1.026	1.000	1.015	1.015
2018-2023	1.025	1.025	1.026	1.000	1.015	1.015
2023-2028	1.025	1.025	1.026	1.000	1.015	1.015
2028-2033	1.025	1.025	1.026	1.000	1.015	1.015
2033-2038	1.025	1.025	1.026	1.000	1.015	1.015

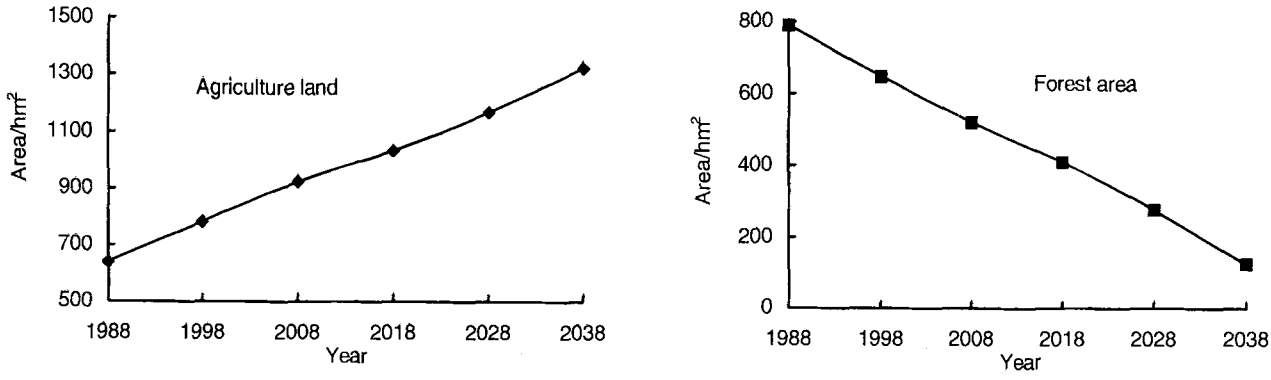

Fig. 1 Agriculture land and forest area after transferring in scenario 1

From Fig. 2, forest land will all be transferred to agricultural land in 2030, at the rate of 24% per year, due to high population pressure, which means after 2030 there will be no forest in Jutpani village.

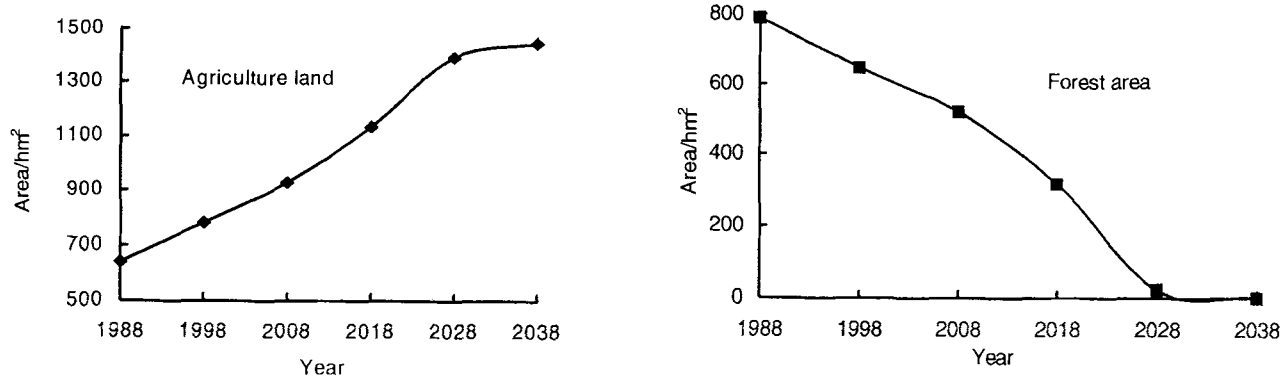

Fig. 2 Agriculture land and forest area after transferring in scenario 2

Conclusions

The Jutpani village has been losing its forest due to agriculture expansion. The process of deforestation is still going on, and unlikely to cease in the future. However the rate of deforestation is expected to slow down to gain time for foresters to make strategy of reducing the serious situation. According to the simulation if the agriculture productivity does not increase or little increase, more forestland will be transferred to agricultural land to meet the local people subsistence life, and deforestation will be more serious at the rate of 24% annually in the Jutpani village. The result is no forest left after 30 years. However if the government strengthens the agriculture production, the deforestation speed will slow down at the rate of 17% annually.

The forestry in Jutpani Village is now facing the serious problem. With the migration and steadily increase of population, a large quantity of forest is swallowed by human activities. In order to alleviate this situation, following suggestions are picked up:

1) To control the population migration and population increase.

2) In order to maintain the forest area, it is very necessary to adopt the agriculture productivity improvement techniques by using more fertilizers, high–yielding crop varieties, and more effective irrigation system, i.e. more agricultural intensification.

3) To establish the plantation for environmental protection purpose along the roads, rivers as well as the agricultural land boundary and around the yard.

4) To improve the local people's awareness of forest importance to global, to plant more trees in the settlement area, and to provide much fuel wood and fodder and improve the agro-forest.

For developing countries, forest and agriculture have close relationship. The expanse of requiring the agricultural land is nibbling the forest. So APM is an invaluable tool for planning as it can stimulate a variety of alternative land. Specially, it is useful in determining impact of expected growth projections and policy initiatives with respect to land use change and deforestation. APM is designed to simulate change for 50 years.

References

CBS (Central Bureau of Statistics). 1998. Statistical pocket book [M]. Nepal: His Majesty's Government National Planning Commission Secretariat, p227.

FAO. 1986. Users guide to Area Production Model (APM) [M]. Asia-Pacific Region; GCP/RAS/JPN. Field Document, p65.

FAO.1997. State of the World's Forests [M]. USA. p21.

FORESC (Department of Forest Research and Survey). 1999. Forest cover change analysis based on LRMP data and Topographic maps [M]. Kathmandu, Nepal: FORESC, p11.

Hussin, Y., A. De gier & Hargyono. 1994. Fores cover change detection analysis using remote sensing: A test for spatially resolved area production model [C]. In: 5th European Conference and Exhibition on GIS and EGIS, Paris, France. p1825-1834.

Hussin, Y., Bode, J. & A. De gier. 1995. The Crystal Globe: a GIS based operational area production model [C]. In: Proceedings 16th Asian Conference on Remote Sensing. Surannarnee University of Technology, Naknon Ratchasima, Thailand. pQ-81–Q-87.